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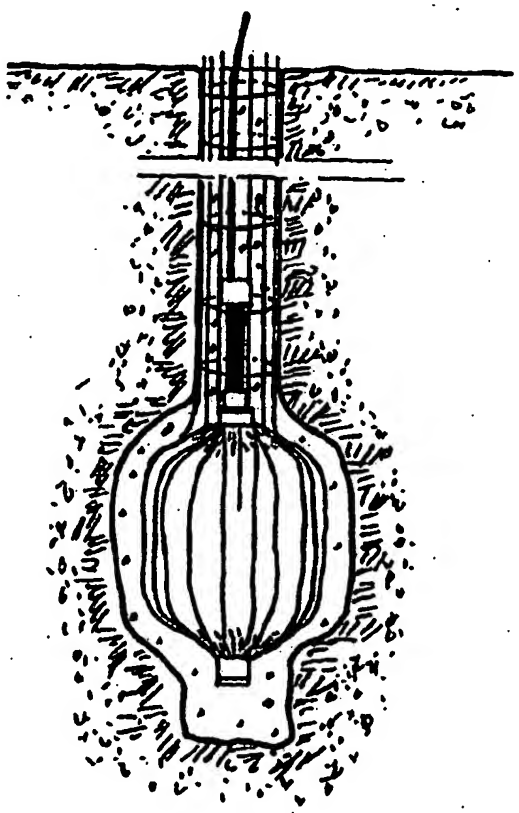
(54) Title: A METHOD OF MAKING CAST-IN-SITU PILES

(57) Abstract

By making a foot on a cast-in-situ pile, for example an auger pile, the load carrying capacity is increased. An inflatable body (18) made of sheet steel folded in a zigzag pattern is placed in the concrete at the bottom of the pile and it is inflated when the concrete has hardened but not hardened so much that it prevents the inflation. The inflation will consolidate the soil around the foot.



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A method of making cast-in-situ piles

This invention relates to a method of making a cast-in-situ pile by making a hole in the ground and filling it with concrete.

Usually, such piles have a diameter of 30-80 cm. They are so called friction piles that take their load on the envelope surface. The point bearing area, that is, the cross section area, makes usually only a minor contribution to the load carrying capacity since the soil is usually not consolidated at the bottom end of the pile. The large cross section area is necessary to make a large envelope area and the pile itself has a strength that could take much heavier loads than the friction permits.

It is an object of the invention to increase the load carrying capacity of cast-in-situ piles or alternatively to reduce the area of the piles without reducing the load carrying capacity. To this end, the invention has been given the characteristics defined in the claims.

The invention will be described with reference to the accompanying drawings that show the making of a cast- in-situ pile. Figures 1-6 show various stages of the work and Figur 7 shows on an enlarged scale details that are shown in Figures 3-6.

Figur 1 shows a drilling rig 11 with a drilling machine 12 and an auger drill 13. The auger drill 13 has a central tube 14 that ends at the front end of the drill and has a fitting 16 at its rear end coupled to the tube 14 through a non-illustrated swivel joint.

When making a pile, one drills down the auger drill 13 in the soil as shown in Figur 1. Then, one couples the fitting 16 to a non-illustrated injection pump for liquid concrete and simultaneuously with withdrawing the drill without rotating it one fills the hole under the drill with concrete as shown in Figur 2.

When the drill 13 has been withdrawn from the hole 17, and the hole has been filled with concrete, a closed inflatable body (expander body) 18 of tightly folded steel sheet is forced down to the bottom of the hole 17 as shown in Figur 3. The expander body is not shown and descibed in detail, but it is described in WO88/00261, EP-0079875-A and EP-0112316-A which are incorporated herein by way of reference. The inflatable body 18 is made of a double steel sheet that is sealed both at its edges and at its ends and is tightly folded in a zigzag pattern. A pressure hose 20 is coupled to a tube 19 that is part of the inflatable body 18, and a reinforcement cage 21 is fixed to the tube 19.

When the inflatable body (expander body) 18 and the reinforcement cage 21 are in place, the pile is left until the concrete has hardened but not yet received too high a strength. It can bee left for example one or a few hours and up to 24 hours depending on the quality of the concrete. Then the expander body 18 is inflated by being injected with cement grout which can be made of cement only or cement with an addition of fine sand. An injection pump is used that has a pressure capacity in the order of 10 megapascal (100 bar). Suitably, the concrete in the hole should have hardened only so much that it will recover plasticity during the expansion of the body 18. It must, however, be so strong that it will be affected only close to the body 18 and so that it will not be forced upwards in the hole 17. The suitable hardening time will be empirically found and it can be controlled by

conventional additives to concrete. Thus, an enlarged foot of the pile will be formed.

The expander body will contract axially when it expands radially as shown on Figures 4-6. An expander body that has a final diameter of 80 cm can originally be square with 12 cm sides and it contracts about 30 cm. In total, this contraction causes a volume reduction of 5 liters in the axial direction and half this volume reduction will normally be localised to the bottom end of the body 18. This volume reduction of a few litres should, however, be considered in relation to the radial expansion of the body which is in the order of 1000 litres. The soil around the expander body 18 is subject to the expansion pressure and since the body expands radially directly adjacent the small axial volume reduction, the pressure will cause the concrete and the earth to move so that there will be a positive pressure under the expansion body 18 instead of a subpressure. This pressure will correspond to the pressure during a conventional injection in the soil, and it will consolidate the soil and increase the capacity of the soil around the expander body 18.

In some formations. it is advantageous to make an underinjection that is heavier than the one that results from the expansion only, and to this end, the body 18 can have a valve at its bottom that permits the grout in the body to be forced out of the body in direct in connection with the finalized expansion as shown by the arrows 23 in Figur 5. This valve can be so arranged as to be controlled manually by a line that extends up through the pressure hose 20. Alternatively it can be arranged to open in response to the axial contraction of the expander body.

In particular when the concrete is allowed to harden as much before the expansion that it cracks instead of becoming

plastic during the expansion, it can be advantageous to underinject. Sometimes, it can be advantageous to underinject a while after the expansion of the body 18. The injection can then be carried out through a separate hose that extends outside the body 18.

In Figure 7, the upper part of the expander body 18 is shown before the body has been expanded, and the tube 19, the hose 20 and the reinforcement cage 21 are also shown. The cage 21 is shown fixed to the tube 19 by being welded thereto. Four rebars 22 of the cage 21 extend forwardly and are fixed to the middle part of the expander body 18 by being welded thereto. The tube 19 is a telescopic tube that comprises an outer tube 23 to which the cage 21 is welded and an inner tube 24 that is welded to the expander body and moves outwardly relative to the outer tube 23 when the expander body 18 contracts and thus it compensates for the contraction. The middle portion of the expander body does not move when the expander body 18 expands radially. The expansion will however force the rebars 22 outwardly and bend them so that they are pulled downwardly 1-2 dm and the cage 21 should therefore be adapted to permit this movement downwardly without being pulled downwardly in its entirety. Alternatively, the rebars 22 should not be fixed axially to the expander body 18.

In the above described method, the expansion body 18 is forced down into the concrete in the hole 17. Alternatively, the auger drill 13 can be adapted to allow the expander body 18 to be moved down through the central tube 14 of the expander body 18 before the hole 17 is filled with concrete.

The hole 17 can be made in other ways than being drilled with an auger drill and when an auger drill is used, the drill can be withdrawn before the hole is filled with concrete if the soil so permits. Then, the expander body 18

and the reinforcement cage 21 can be inserted in a hole which is then filled with concrete.

In order to permit for the expander body 18 to be expanded independently of the hardening time of the concrete, sand or gravel can be filled in the hole around the expander body 18 and concrete be filled in the hole above the expander body. The compaction of the soil and the reinforcement of the soil that results from the sand being forced into the soil will still make up for a good end bearing capacity although it will not always be as good as the end bearing capacity when there is concrete around the expander body. However, underinjection as described above can be carried out to improve the end bearing capacity.

Claims

1. A method of making a pile by making a hole in the soil and filling it with concrete, characterized by the steps of introducing an inflatable body (18) in the hole (17) and expanding the body (18) to form an enlarged foot of the pile when the concrete has hardened in the hole.

2. A method according to claim 1, characterized in that concrete is filled around the inflatable body (18) and the body is inflated when the concrete has hardened but not hardened more than it will again plasticize around the body during the inflation.

3. A method according to claim 1 or claim 2, characterized in that the inflatable body (18) is inflated by being injected with cement grout.

4. A method according to any one of the preceding claims, characterized by the step of injecting grout into the soil under the body (18) after the expansion of the body.

5. A method according to claim 4, characterized in that one inflates the body (18) and injects under the body with the same grout.

6. A method according to claim 5, characterized in that the grout for injection is supplied from the interior of the body (18).

7. A method according to claim 6, characterized in that the grout is supplied at the end of the inflation operation through a valve at the bottom end of the body (18).

8. A method according to claim 7, characterized in that the valve is operated in response to the axial contraction of the inflatable body (18).

9. A method according to any one of the preceding claims, characterized in that an inflatable body (18) is used that comprises a tightly folded steel sheet.

10. A method according to claim 9, characterized in that the inflatable body (18) that is used comprises a double steel sheet that is folded in a zigzag pattern.

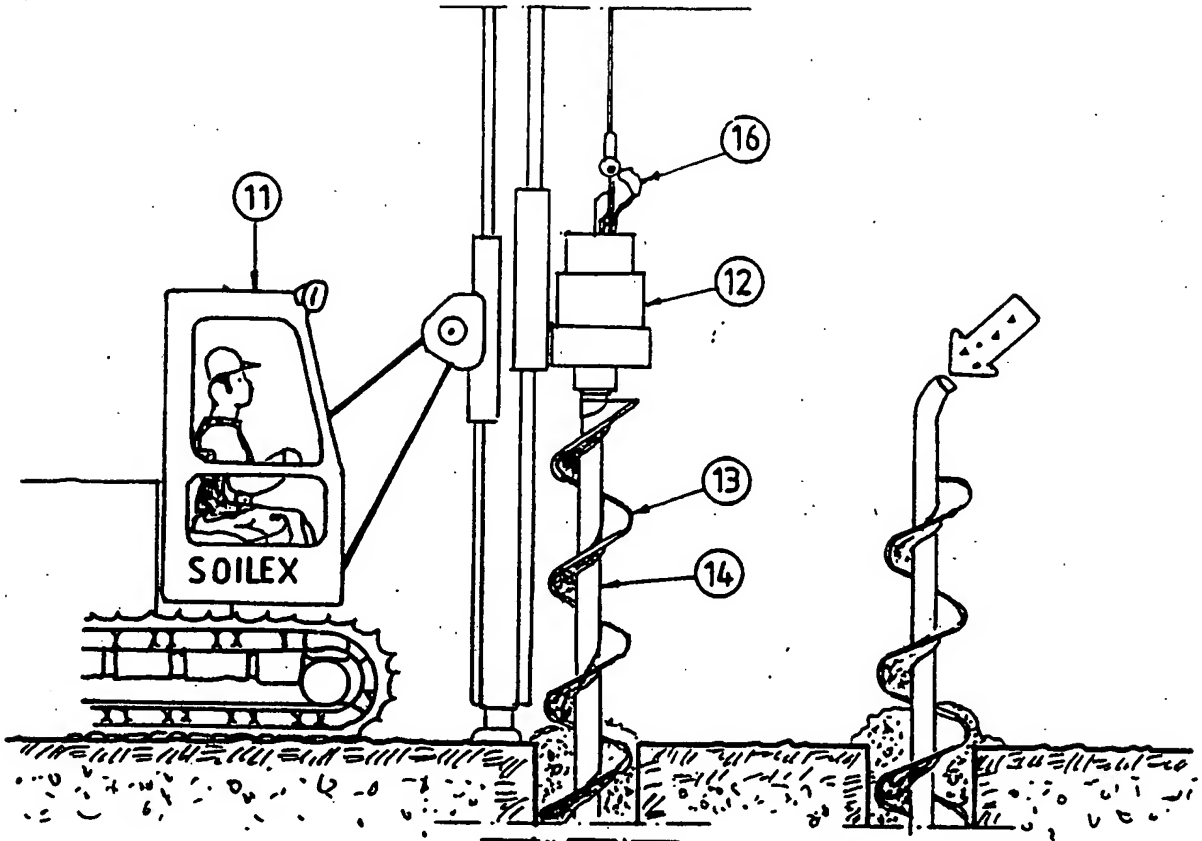

FIG 1

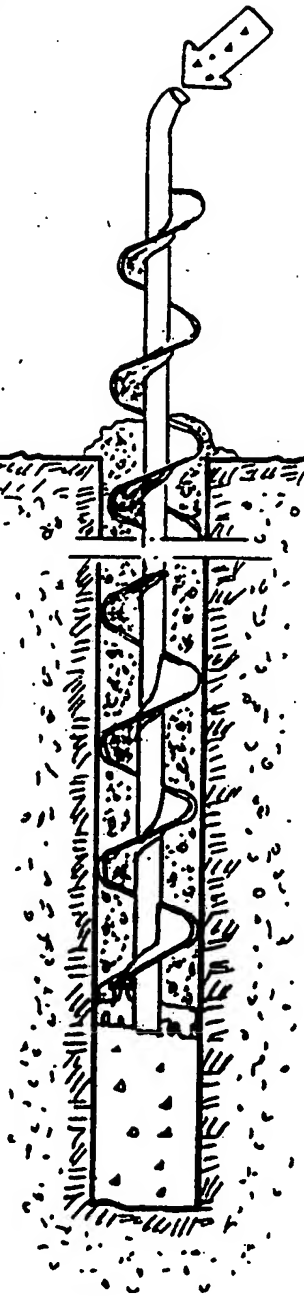

FIG 2

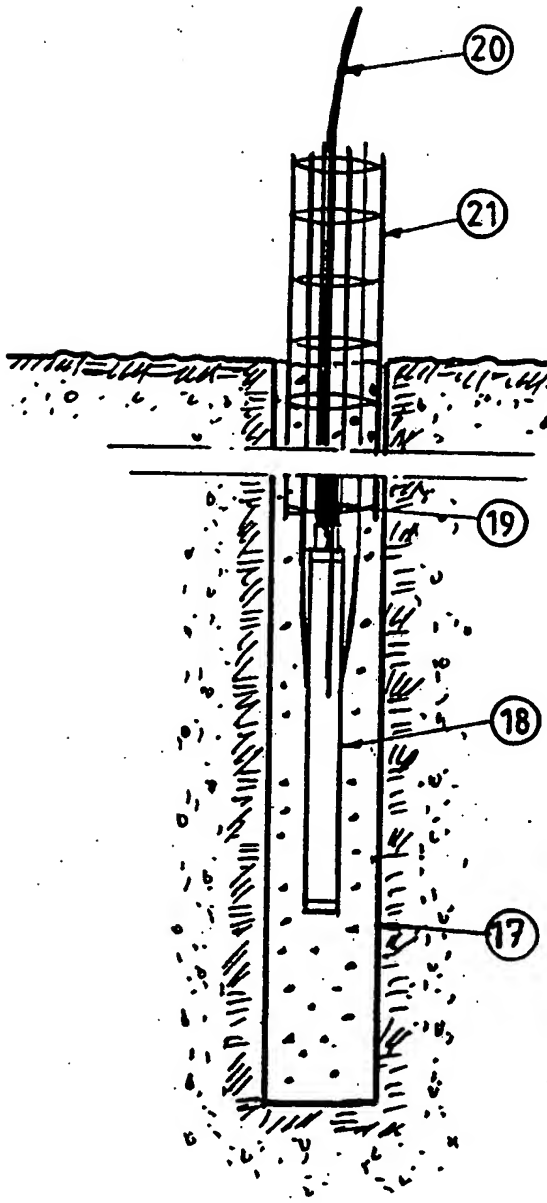

FIG 3

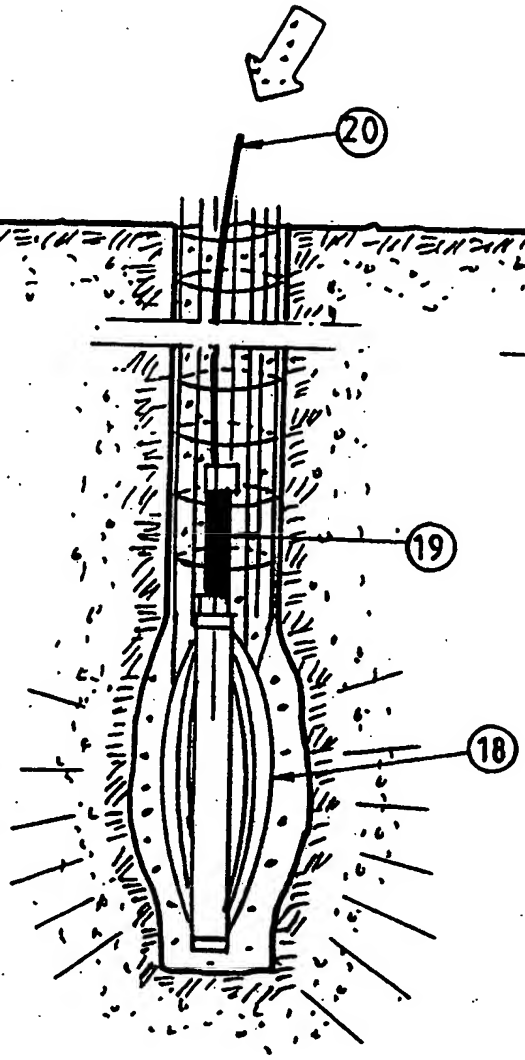

FIG 4

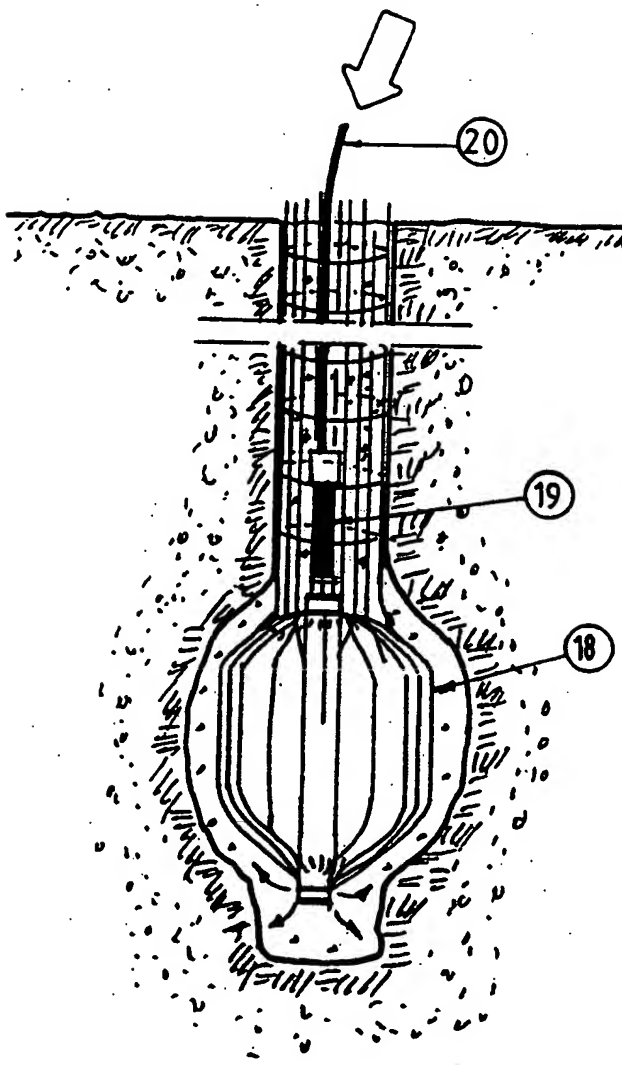

FIG 5

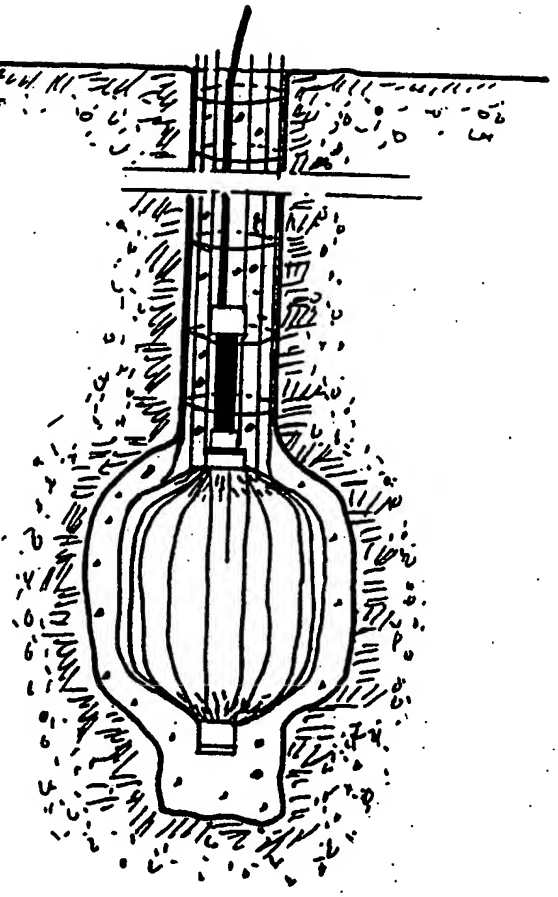

FIG 6

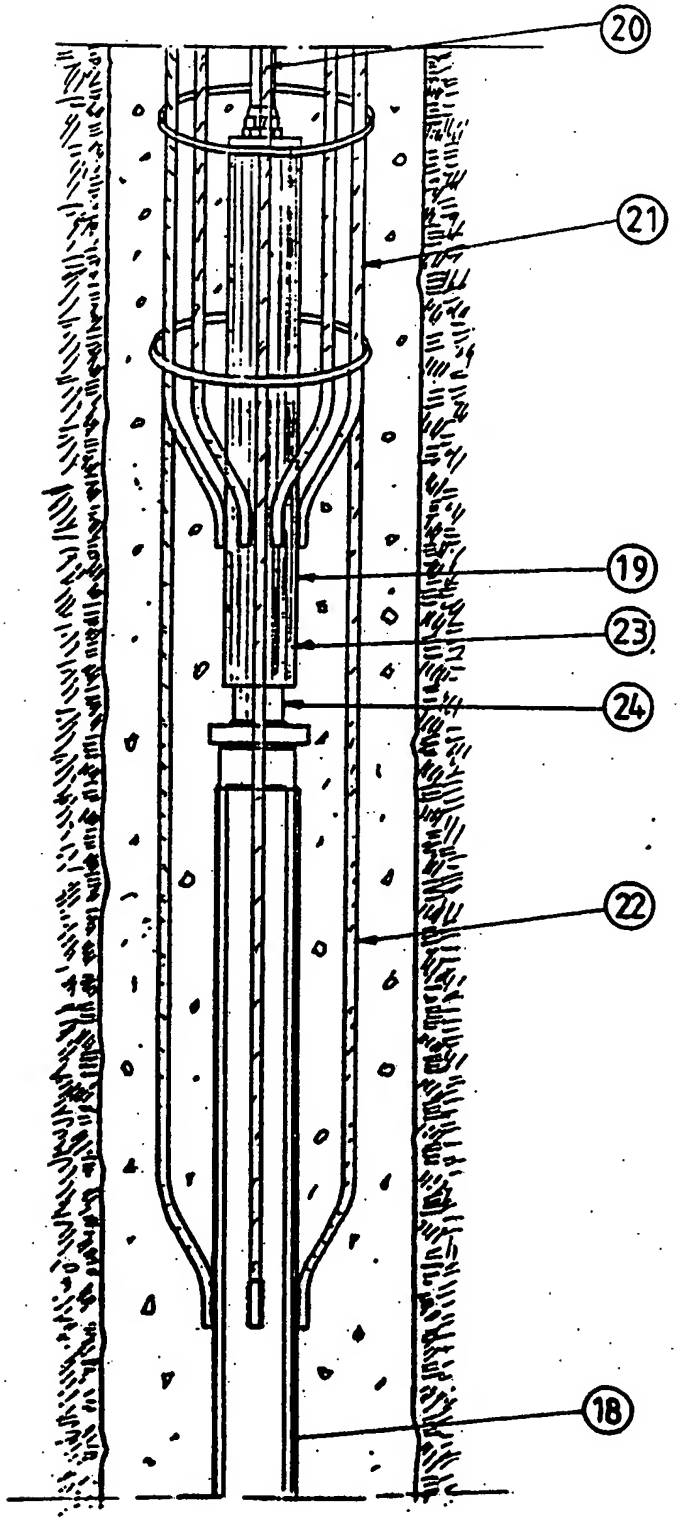

FIG 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 94/00282

A. CLASSIFICATION OF SUBJECT MATTER

IPC5: E02D 5/44, E02D 5/62
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

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IPC5: E02D, E21D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	SE, T3, 179836 (WEDJE PILE AND ANCHORAGE LTD), 4 January 1989 (04.01.89), page 5, line 11 - line 14; page 5, line 20 - line 21	1-10
A	US, A, 3375670 (S. SEROTA), 20 November 1966 (20.11.66), page 1, line 27 - line 29	1-10
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[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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A	SE, B, 436781 (ATLAS COPCO AB), 21 January 1985 (21.01.85), page 1, line 9 - line 16	1-10

INTERNATIONAL SEARCH REPORT
Information on patent family members

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		AU-A- 4238485	28/11/85
		GB-A,B- 2170847	13/08/86
		JP-T- 61502001	11/09/86
		US-A- 4768900	06/09/88
		WO-A- 8505137	21/11/85
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		EP-A,B- 0079875	25/05/83